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RADIUM

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VOL. XVII JULY, AUGUST, 1921 Nos. 4-5

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A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY PHYSICS AND THERAPEUTICS OF RADIUM AND RADIO-ACTIVE SUBSTANCES

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RADIUM

A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY, PHYSICS AND THERAPEUTICS OF RADIUM AND RADIO-ACTIVE SUBSTANCES

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Edited by Charles H. Viol, Ph. D., and William H. Cameron, M. D with the assistance of collaborators working in the fields of Radiochemistry, Radioactivity and Radiumtherapy.

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VOL. XVII JULY, AUGUST, 1921 Nos. 4-5

THE DANGERS IN WORKING WITH RADIUM AND X-RAYS. HOW THE PROBLEM IS BEING MET.

During the past seven months many references have been made in the medical literature to the dangers encountered by those who work more or less constantly with radium and with the high intensity penetrating x-rays such as are now used in the massive dose treatment work. A knowledge of these dangers and of the means of avoiding serious effects is of the greatest importance to all who are using radium and x-rays, and in the following excerpts from the literature the recognized dangers and suggestions of means for avoiding them are given.

The London correspondent of the Journal of the American Medical Association, J.A.M.A. vol. 76, p. 1412, May 21, 1921, says:

"Recently I reported the deaths of three workers at the Radium Institute which were attributed to aplastic anemia due to their occupation. The matter was first published here through a circuitous channel, being derived from a French report. An official report has now been made by the medical superintendent of the institute, Mr. Hayward Pinch, which considerably modifies the previous one. The first death occurred in December, 1916, in a worker who was seen by several eminent specialists and whose death was ascribed by them to pernicious anemia. The second death occurred in January, 1920, in a nurse, and was due to infective endocarditis; but it is admitted that the radium had unquestionably affected her, though it was not from this alone that she died. The third death occurred in February, 1921, in a man, aged 47, and was due to acute pneumonia. Each case is claimed to have been due to a definite disease apart from the effects of radium, but the institute committee considered it highly probable that the work of these persons

weakened the powers of resistance to the diseases from which they suffered. Dr. J. C. Mottram was appointed to make a special investigation of the effects of radium on the staff of the institute. For a year he made examinations of the blood of every worker, from the superintendent down to the hall porters. He found definite changes in the red and white corpuscles due to exposure to radium. He showed that radium workers are subject to widely different amounts of irradiation varying as they work near to or distant from radium and according to the period of exposure. Laboratory workers who prepare and measure applicators containing emanation and radium, and clinical workers who attach screens to the radium applicators and subsequently apply them to patients are especially exposed. Other workers, down to the servants of the institution, are subject to only small quantities of the gamma radiation, which pervades the whole building. The polymorphonuclear, leukocytic, and lymphocytic blood count of radium workers was found decidedly lower than that of normal persons. Even among the less irradiated workers there was no evidence of leukocytosis. This contrasts with the fact that in small animals alternate periods of irradiation and freedom from irradiation will under certain conditions produce profound leukocytosis, and that the leukopenia following a single dose of roentgen rays is often followed by leukocytosis. The leukopenia of radium workers is manifest after a few weeks' exposure. No association was found between the leukopenia and any ill health. An extremely thorough protective system has been elaborated and has been copied by other institutes. Dr. Motram has recently reported, after a year's blood examinations of the workers, that their blood condition is slowly returning to normal."

In the same issue (J.A.M.A. p. 1413), the Paris correspondent says:

"In providing for the protection of operators against the possible damaging effects of scattering roentgen rays, thus far consideration has been given exclusively to lateral protection by surrounding the roentgen-ray apparatus with double lead screens from 5 to 6 mm. thick. But against the vertical radiations no protection has been provided. The fact remains that persons who occupy the floors above and below the apparatus are exposed to intense applications of roentgen rays. Deep roentgen-ray therapy requires for the treatment of cancer a high intensity of the rays, in France a spark gap of 25 cm. and one sitting of from twelve to fifteen hours, and in Germany a spark gap of 12 cm. and one sitting of five hours being employed. The irradiation produced by such intensity possesses an immense power of penetration. Monsieur Contremoulins, who lately called the attention of the Academy of Science to these facts, thinks that such high-powered apparatus cannot be installed in densely populated urban centers without exposing the inhabitants to grave dangers. Special measures of protection must therefore be provided."

Dr. Mottram, director of the Research Department of the London Radium Institute, makes the following report in the annual report of that institution (for the year of 1920) which has recently been published.

"Since the last report a second paper dealing with the blood of the workers at the institute has been published (Archives of Radiology and Electrotherapy, December, 1920), and read before the Pathological Society of Great Britain and Ireland, August, 1920. In this communi-

cation the red cell content was dealt with. In several cases a mild anaemia was found, down to 4,150,000 per cubic millimetre for males and 3,300,000 for females. In all these cases the color index was above the normal."

"The paper also describes three cases of death amongst radium workers, two in this country and one in France. In two of these cases death was ascribed to aplasic pernicious anaemia, in the third case the blood condition was similar but the case was complicated by signs of infective endocarditis. From these two sets of facts—the mild anaemia of the pernicious type found among the workers, and the three deaths accompanied by profound aplasic pernicious anaemia, it was concluded that exposure to radium was the important aetiological factor."

"The association of this condition of anaemia with a polynuclear leucopenia, previously reported, indicated that the case is a direct action of the radium (gamma radiation) upon the bone marrow."

"In order to test this assumption a series of rats have been exposed to varying amounts of gamma radiation. The bone marrows were then removed, and compared with those of normal animals. A decrease in the number of mitoses in the radiated specimens was observed, indicating a decreased output of blood cells."

"Details of these experiments are given in the Archives of Radiology and Electrotherapy, December, 1920—"Histological changes in the bone marrow of rats exposed to the gamma radiation of radium." The results confirm the view that the effects found among the radium workers are due to gamma ray exposure."

"During 1920 increased protection from radium for the workers was instituted (see last report), and as a result the blood condition of the workers is already (February, 1921) returning to the normal. Details of this return to the normal will be given in the next report."

Referring to recent papers by Drs. Regaud and Tuffier, the Paris correspondent of the Journal of the American Medical Society (J. A. M. A. vol. 77, p. 298, July 23, 1921), gives the following:

"At recent sessions of the Academy of Medicine, considerable attention was given to the dangers of radium. Dr. C. Regaud (Bul. de l'Acad. de Med. v. 85, p. 608, May 21, 1921), director of the biologic laboratory and the therapeutic service of the Radium Institute of the University of Paris, presented an interesting communication on the subject, from which I take the following excerpts: The accidental absorption, by inhalation, of radium emanations is not dangerous except in a confined space. The rays of radioactive substances present for the skin and deep-seated organs (and especially for the hematopoietic system) dangers similar to those connected with roentgen rays. Operators and attendants can protect themselves by forming the habit of: (1) taking judicious advantage of the law of distance (especially through the use of special tongs in performing manipulations), and (2) interposing between the operator's body and any source of radiation leaden screens several centimeters thick and impervious to penetrating rays. The few accidents that have happened up to the present time have been the result of ignorance of the danger and lack of precautions. Regaud believes that in a well organized establishment with an instructed and well trained personnel, the nurses and others near the patients under treatment will not run any risk through the action of radioactive bodies. Dr. Tuffier (Bul. de l'Acad. de Med. v. 85, p. 617,

May 31, 1921), professor at the school of medicine of the University of Paris, was anxious to obtain documentary information on the dangers of radium from the important American centers where radium has been in use for a long time and in large quantities, since there entire hospitals are devoted to the study of radioactive action. He has received replies from the cancer commission of Harvard University, the Howard A. Kelly Hospital in Baltimore and the Mayo Clinic. At the Mayo Clinic no menstruation troubles of any kind have been observed among the nurses handling radium applicators. There have been only accidents of a local nature, such as cutaneous lesions, not at all serious. To prevent accidents happening the personnel is changed very often. However, the cancer commission of Harvard University, and the Kelly Hospital gave him the following information: Soon after the study of radium therapy was begun, several cases of menstrual and general disturbances were noted among the nurses in charge of radium applicators. These disturbances occurred when the nurses were in contact with radium for two or three months in succession. They disappeared when the nurses left this service. Five cases have been noticed during recent months, and since that time a rotatory schedule has been established to prevent these accidents, so that now no nurse remains longer than two months in the service, and they are taught not to handle radium tubes without using tongs, and to keep them in a box specially constructed to prevent radiation. At Harvard University manifestations of azoospermia were also noted, but these disappeared after a few months when the operators were protected against radiation. At the Kelly Hospital, where the operators have had a great deal of experience in handling radium, a careful study has been made concerning accidents due to radiation. A reduction of polymorphonuclear elements and an increase of lymphocytes in the blood were noted, sometimes also a slight leukopenia. The disturbances that were noted at the beginning disappeared, thanks to precautions taken by the nurses. Time is the most important factor in the case, for since the nurses have been changed every month no disturbances have been noted either in menstruation or in the blood. The results of this inquiry show that accidents occurring through the handling of radium can be prevented by taking into account the duration of service and the factor of distance in the application of radium."

In discussing the dangers of radium, Bul. de l'Acad. de Med. vol. 85, p. 660, June 7, 1921, quoted in abstract (J.A.M.A. p. 323, July 23, 1921):

"Broca presents the report of the committee appointed to study this subject. It states "The dangers are real, but they are easily avoidable, with proper precautions, for all except the manipulators of the emanation and during radioscopy. But society has to have these regardless of the danger, just as physicians have to expose themselves daily to contagious diseases. The probability of injury is about the same in both these fields, but the dangers are faced by men who accept them in view of the importance of the task, and who know the precautions to be taken." . . . 'If some of them suffer in consequence of their devotion, notwithstanding the known precautions, the instances will be rare, and they will be accompanied by our respect and our gratitude.'"

In England a committee was appointed to consider x-ray and radium protection and in the June 25th issue of the British Medical Journal, pp. 936-7 there is given a preliminary report of this committee, which is herewith reproduced.

"The x-ray and radium protection committee, representing the various radiological and other scientific bodies with their headquarters in the metropolis, after deliberating for some weeks, has issued its preliminary report, which is admittedly tentative in some of its recommendations. This report, which is a carefully thought out statement of present knowledge in regard to equipment, ventilation, and working conditions of x-ray and radium departments, was a matter of considerable urgency owing to the constant demand for guidance from individuals and institutions; it is printed in full below. After the completion of this, the preliminary part of its work, the committee intends to proceed with its more extensive objects which may entail considerable research."

"The chairman of the committee is Sir Humphry Rolleston, K.C.B. The other members are: Sir Archibald Reid, K.B.E., C.M.G. (St. Thomas's Hospital), Dr. Robert Knox (King's College Hospital), Dr. G. Harrison Orton (St. Mary's Hospital), Dr. S. Gilbert Scott (London Hospital), Dr. J. C. Mottram (Pathologist, Radium Institute), Dr. G. W. C. Kaye, O.B.E. (National Physical Laboratory), and Mr. Cuthbert Andrews. The honorary secretaries are Dr. Stanley Melville (St. George's Hospital) and Professor S. Russ (the Middlesex Hospital)."

"Suggestions and offers of personal or other assistance are invited, and should be sent to the honorary secretaries of the committee, care of Royal Society of Medicine, 1 Wimpole Street, W.1. Copies of the preliminary report may be had on application to the honorary secretaries."

"*Introduction.* The danger of over-exposure to x-rays and radium can be avoided by the provision of efficient protection and suitable working conditions. The known effects on the operator to be guarded against are: (1) Visible injuries to the superficial tissues which may result in permanent damage. (2) Derangements of internal organs and changes in the blood. These are especially important, as their early manifestation is often unrecognized."

"*General Recommendations.* It is the duty of those in charge of x-ray and radium departments to ensure efficient protection and suitable working conditions for the personnel.

The following precautions are recommended:

1. Not more than seven working hours a day.
2. Sundays and two half-days off duty each week, to be spent as much as possible out of doors.
3. An annual holiday of one month, or two separate fortnights.

Sisters and nurses, employed as whole-time workers in x-ray and radium departments, should not be called upon for any other hospital service.

"*Protective Measures.* It cannot be insisted upon too strongly that a primary precaution in all x-ray work is to surround the x-ray bulb itself as completely as possible with adequate protective material, except for an aperture as small as possible for the work in hand.

The protective measures recommended are dealt with under the following sections:

I. X rays for diagnostic purposes.
II. X rays for superficial therapy.
III. X rays for deep therapy.
IV. X rays for industrial and research purposes.

V. Electrical precautions in x-ray departments.
VI. Ventilation of x-ray departments.
VII. Radium therapy.

It must be clearly understood that the protective measures recommended for these various purposes are not necessarily interchangeable; for instance, to use for deep therapy the measures intended for superficial therapy would probably subject the worker to serious injury.

I.—X-Rays for Diagnostic Purposes

"(1) *Screen Examinations.* (a) The x-ray bulb to be enclosed as completely as possible with protective material equivalent to not less than 2 mm. of lead. The material of the diaphragm to be equivalent to not less than 2 mm. of lead."

"(b) The fluorescent screen to be fitted with lead-glass equivalent to not less than 1 mm. of lead, and to be large enough to cover the area irradiated when the diaphragm is opened to its widest. (Practical difficulties militate at present against the recommendation of a greater degree of protection.)"

"(c) A traveling protective screen, of material equivalent to not less than 2 mm. of lead, should be employed between the operator and the x-ray box."

"(d) Protective gloves to be of lead-rubber (or the like) equivalent to not less than one-half mm. of lead and to be lined with leather or other suitable material.. (As practical difficulties militate at present against the recommendation of a greater degree of protection, all manipulations during screen examination should be reduced to a minimum)."

"(e) A minimum output of radiation should be used with the bulb as far from the screen as is consistent with the efficiency of the work in hand. Screen work to be as expeditious as possible."

"(2) *Radiographic Examinations ('Overhead' Equipment).* (a) The x-ray bulb to be enclosed as completely as possible with protective material equivalent to not less than 2 mm. of lead."

"(b) The operator to stand behind a protective screen of material equivalent to not less than 2 mm. of lead."

II.—X-Rays for Superficial Therapy.

"It is difficult to definite the line of demarcation between superficial and deep therapy. For this reason it is recommended that, in the reorganization of existing, or the equipment of new, x-ray departments small cubicles should not be adopted, but that the precautionary measures suggested for deep therapy should be followed. The definition of superficial therapy is considered to cover sets of apparatus giving a maximum of 100,000 volts (15 cm. spark-gap between points; 5 cm. spark-gap between spheres of diameter 5 cm.)"

"*Cubicle System.* Where the cubicle system is already in existence it is recommended that:

"1. The cubicle should be well lighted and ventilated, preferably provided with an exhaust electric fan in an outside wall or ventilation shaft. The controls of the x-ray apparatus to be outside the cubicle.

"2. The walls of the cubicle to be of material equivalent to not less than 2 mm. of lead. Windows to be of lead-glass of equivalent thickness."

"3. The x-ray bulb to be enclosed as completely as possible with protective material equivalent to not less than 2 mm. of lead."

III.—X-Rays for Deep Therapy.

"This section refers to sets of apparatus giving voltages above 100,000.

"1. Small cubicles are not recommended."

"2. A large, lofty, well ventilated and lighted room to be provided."

"3. The x-ray bulb to be enclosed as completely as possible with protective material equivalent to not less than 3 mm. of lead."

"4. A separate enclosure to be provided for the operator, situated as far as possible from the x-ray bulb. All controls to be within this enclosure, the walls and windows of which to be of material equivalent to not less than 3 mm. of lead."

IV.—X-Rays for Industrial and Research Purposes.

"The preceding recommendations for voltages above and below 100,000 will probably apply to the majority of conditions under which x-rays are used for industrial and research purposes."

V.—Electrical Precautions in X-Ray Departments.

"The following recommendations are made:

"1. Wooden, cork, or rubber floors should be provided; existing concrete floors should be covered with one of the above materials."

"2. Stout metal tubes or rods should, wherever possible, be used instead of wires for conductors. Thickly insulated wire is preferable to bare wire. Slack or looped wires are to be avoided."

"3. All metal parts of the apparatus and room to be efficiently earthed."

"4. All main and supply switches should be very distinctly indicated. Wherever possible double-pole switches should be used in preference to single-pole. Fuses no heavier than necessary for the purpose in hand should be used. Unemployed leads to the high-tension generator should not be permitted."

VI.—Ventilation of X-Ray Departments.

"1. It is strongly recommended that the x-ray department should not be below the ground level."

"2. The importance of adequate ventilation in both operating and dark rooms is supreme. Artificial ventilation is recommended in most cases. With very high potentials coronal discharges are difficult to avoid, and these produce ozone and nitrous fumes, both of which are prejudicial to the operator. Dark rooms should be capable of being readily opened up to sunshine and fresh air when not in use. The walls and ceilings of dark rooms are best painted some more cheerful hue than black."

VII.—Radium Therapy.

"The following protective measures are recommended for the handling of quantities of radium up to one gram:

"1. In order to avoid injury to the fingers the radium, whether in the form of applicators of radium salt or of emanation tubes, should always be manipulated with forceps or similar instruments, and it should be carried from place to place in long-handled boxes lined on all sides with 1 cm. of lead."

"2. In order to avoid the penetrating rays of radium all manipulations should be carried out as rapidly as possible, and the operator

should not remain in the vicinity of radium for longer than is necessary. The radium, when not in use, should be stored in an enclosure, the wall thickness of which should be equivalent to not less than 8 cm. of lead."

"3. In the handling of emanation all manipulations should, as far as possible, be carried out during its relatively inactive state. In manipulations where emanation is likely to come into direct contact with the fingers thin rubber gloves should be worn. The escape of emanation should be very carefully guarded against, and the room in which it is prepared should be provided with an exhaust electric fan."

"*Existing Facilities for Ensuring Safety of Operators.* The governing bodies of many institutions where radiological work is carried on may wish to have further guarantees of the general safety of the conditions under which their personnel work."

"1. Although the committee believe that an adequate degree of safety would result if the recommendations now put forward were acted upon, they would point out that this is entirely dependent upon the loyal co-operation of the personnel in following the precautionary measures outlined for their benefit."

"2. The committee would also point out that the National Physical Laboratory, Teddington, is prepared to carry out exact measurements upon x-ray protective materials and to arrange for periodic inspection of existing installations on the lines of the present recommendations."

"3. Further, in view of the varying susceptibilities of workers to radiation, the committee recommend that wherever possible, periodic tests—for example, every three months—be made upon the blood of the personnel, so that any changes which occur may be recognized at an early stage. In the present state of our knowledge it is difficult to decide when small variations from the normal blood count become significant."

In the United States over 50 grams of radium element is now in use for therapeutic application and all are aware of the more extended use made of the x-rays following the development of the Coolidge tube. The dangers from these agents on those who work with them are great, and as in England, so here there should be a committee which would give such matters careful study. An active joint committee representing the American Radium Society, the American Roentgen Ray Society and the Radiological Society of North America could make a good start in this work and suggest necessary precautions, as well as lines for study.

REPORT OF CASE OF GASTRIC CARCINOMA

By C. J. Johanneson, M.D., St. Mary's X-Ray Laboratory, Walla, Walla, Wash.

Patient, male, 42 years old, white, was admitted to the Hospital of Hot Lake Sanatorium, Oregon, in a very emaciated condition. For several months had been unable to take any other nourishment but fluid, and for the last few days before arriving at the hospital, he had to vomit up practically all he took per mouth; and was unable to walk, etc.

The history revealed evidence of gastric or duodenal ulcer a few years ago. At time of admission the patient complained of a general "aching" throughout the abdomen, but no distinct "pain point,"—no palpable tumor-mass could be located definitely.

A complete gastro-intestinal radiographic examination was performed which showed a very large stomach, atonic, with persistent "filling defect" of pars pylorica and complete closure of pylorus. A series of plates was taken of the stomach and in 24 hours after the barium-meal was given, nothing had gone through the pylorus. The "filling-defect" was typical of carcinoma. A barium-enema showed the entire colon and caecum negative to pathological findings.

The patient was operated two days after admission by Dr. W. T. Phy, of Hot Lake Sanatorium (Nov. 8, 1920). Dr. Phy found a very large, hard, but friable carcinoma-mass involving the entire pars pylorica and pylorus. Duodenam was apparently negative. Complete closure of pylorus. The mass was so friable that, when Dr. Phy attempted to pick up the stomach, his finger went through the tumor-mass. A posterior gastro-jejunostomy was performed; meanwhile we decided to apply radium, though we had little or no hope for the patient.

Considering the seriousness and extensive involvment, I decided to apply the radium as follows: 25 milligrams, unscreened tube applied within the hole Dr. Phy had accidently made with his finger in the tumor mass, and two needles of 12.5 milligrams, unscreened, each applied (or buried) in the stomach wall near pylorus involved by carcinoma. The tubes and needles were properly anchored.

After this the abdomen was closed and patient removed to a private room, with no expectations of recovery.

After 12 hours exposure to radium the tube and needles were removed, without opening the abdomen.

After a couple of days the patient began to give hope for recovery and showed progress as time went on. Two weeks after the operation I gave the patient a series of x-ray applications covering the entire abdomen and dorso-lumbar region (cross-fire method).

Four weeks after the operation the patient had been walking around in the institution and was allowed to go home. He was able to digest his food, which, of course, was a restricted and outlined diet. He was fast gaining strength and weight. He was told to report back in a month from this discharge.

First part of January, 1921, the patient returned and submitted himself to an exploratory laparotomy, as we were anxious to learn about the result. He had meanwhile gained 24 pounds in weight, could eat anything and everything he wished, the digestion was perfect, and the patient looked like an entirely different person than when he was admitted in November, 1920.

The operation showed that the carcinoma-mass had almost entirely disappeared; only a slight induration about the pars pylorica near the pylorus still showed evidence of malignancy; Dr. Phy decided not to interfere surgically, therefore we again applied radium as follows:

Two needles of 12 5 milligrams, each unscreened, buried in the indurated tissue of pars pylorica on either side of the stomach and the tube containing 25 milligrams, screened with brass capsule, applied in close contact with a small hard mass at duodenum. After this the abdomen was immediately closed up.

After 14 hours exposure to the radium the needles and tube were removed.

The patient left the hospital three weeks after the second operation, though before leaving he was given a series of x-ray applications, same technique and method as after the first operation.

The patient was advised to return in from four to six weeks for x-ray treatments, but did not come until eight weeks from the second operation, when he received a series of x-ray exposures covering the abdomen and back. He was improving rapidly, still gaining weight and said he felt fine now and had no more "stomach trouble."

The patient called at my present office a few days ago (May, 1921), inquiring if I thought it would be necessary to have more x-ray treatments; his present weight is 168 pounds (against 117 when he was admitted in November 1920); said he had not been feeling so well in years; his stomach was working fine; he had been doing all his work on his ranch for the last four or five weeks.

Examining the abdomen we could find no tenderness nor palpable mass. I advised another series of x-ray applications for prophylaxis.

Though I have been working with radium for some years, and in practically all, gynecological work, uterine cancers and fibromas, etc., I have obtained excellent results; this is the first gastric carcinoma in which I have personally seen such an amazing result, and I feel sure the radium application in such cases should be used to much greater extent than it is at the present time, especially in this part of the country. I could hardly have believed the successful result obtained in such a short time in this case, if I had not seen it myself.

The success in this case is to a great extent due to the splendid surgical procedures by Dr. W. T. Phy and his many good advices in the application of radium.

REVIEWS AND ABSTRACTS

J. C. Mottram, M.B., D.P.H. The Red Cell Blood Content of Those Handling Radium for Therapeutic Purposes. Archives of Radiology and Electrotherapy, xxv, 194-197, Dec. 1920. From the Research Department of the Radium Institute, London, presented before the Pathological Society of Great Britain and Ireland, Aug. 3, 1920.

"A paper dealing with the leucocytic blood content of individuals working with radium has already appeared (1920). A leucopenia was found affecting both the polynuclears and the lymphocytes, reduction to one half being of common occurrence. The red cell content has been similarly investigated, except that material gathered from outside the Institute has been included. In many cases a diminution in the number of red cells, with a high color index, was observed. In three cases a profound anæmia was found, and was followed by death after an illness of a few months. These cases will be dealt with separately.

"The red cell counts of the other workers is shown in diagram in Fig. 1, where a comparison is made with the blood of normal individuals. The workers are divided into males and females, laboratory and clinical workers (L. and C. in diagram). The remaining individuals are made up of porters, clerks, etc., who are not directly exposed to radium (N. in diagram), but work in the same building; they serve as a second control."

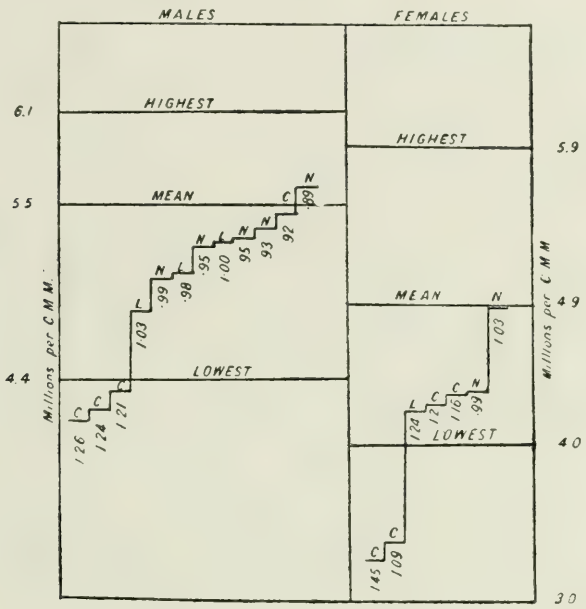


FIG. 1.

C. = Clinical Worker. L = Laboratory Worker.
N. = Unexposed Worker. Numbers below steps = Color Index.

"It is seen that the clinical and laboratory workers present, on the whole, a diminution in the number of red cells as compared with the unexposed workers. However, they fall within normal limits with five exceptions, three male and two female clinical workers. The three males (4·15, 4·2 and 4·3 millions per c.mm.) are a little below the lowest male found by Bing (4·4 millions). The two females (3·3 and 3·4) are, however, very much below Bing's lowest female (4 millions). The hæmoglobin content of these cases shows much less deviation from the normal, so that the color index is high. Referring to the diagram, it is seen that all the unexposed individuals have a color index of close upon 1·0, whereas the color index of the clinical workers is usually in the region of 1·2. The male clinical worker with a lox index and a red cell count of 5·4 millions was away from the Institute during the war for two and a half years. Apart from slight anisocytosis being sometimes present, neither signs of degeneration nor of regeneration were observed."

"These findings would be perhaps of only academic interest were they considered apart from the three fatal cases accompanied by anæmia which have occurred among radium workers. Of these, one was a

female nurse, another a male laboratory worker, and the third a male clinical and laboratory worker. For convenience they will be called Cases A, B and C."

"Case A, æt 36., had been a radium worker for eight years. She had excellent health during this period. She was first noted to be pale on returning from a holiday of two months. Her red cell count was then found to be 2·2 millions per c.mm., and hæmoglobin 50 per cent., color index 1·14. There was considerable anisocytosis."

"The following blood counts were subsequently taken:—

16th day of illness, 1·9 millions; color index, 1·05
26th day of illness, 1·6 millions; color index, 1·09
33rd day of illness, 1·2 millions; color index, ·91
53rd day of illness, 1·1 millions; color index, ·68

"During the period between the last two counts three transfusions of blood were given. She died seventy-three days after being first observed to be anæmic. There was also considerable leucopenia, as is constantly the case in radium workers. The polynuclears numbered between 5-600 per c.mm., and the lymphocytes were usually as numerous. It cannot be said with certainty that death was primarily due to the blood condition, as certain conditions and signs of infective endocarditis were present. No post-mortem examination was obtained."

"Case B, æt 33, had been working with radium for three years. As in the case of A, he was taken ill shortly after returning from a month's holiday. He died three months later. No post-mortem examination was made. Two blood examinations were made:—

24th day of illness, 1·3 millions; color index, 1·2; leucocytes 960
36th day of illness, ·8 millions; color index, 1·3; leucocytes 1,520

"The polynuclears were 960 and 730, the lymphocytes 492 and 790. Anisocytosis was obserbed. The case was diagnosed aplastic pernicious anæmia.

"Case C., æt. about fifty years, had worked with radium for ten years. Previous to this his blood presented some anomalies, notably a mast-cell leucocytosis. His illness was of short duration, and was diagnoed as aplastic pernicious anæmia. No post-mortem examination was made.

"The following blood count was made 20 days before his death:—

Hemoglobin Gowers Sahli, 12·5
Tallquist, < 20 > 10
Globules rouges, 527,500 per mm.^{8} Globules blanc, 850 per mm.^{8}
Valeur globulaire, 0.884
Pourcentage leucocytaire, polynucléaires neutrophils, 13·5
Petit myélocyte neutrophile type de metamyélocyte, 1
Polynucléaires neutrophile avec dégénéresence. 1
Polynucléaires éosinophils, 1·2
Grands mononucléaires, 10
Moyens mononucléaires, 8
Lymphocytes, 40·5
Petits cellules plasmatiques, 24·8

Hematies nucléés environ 4 pour 100 leucocytes, légére poikilocytose, anisocytose tres marqueé, notable polychromatophilic."

"Reviewing these three cases, and taking into account the great rarity of aplastic pernicious anæmia, it might reasonably be concluded

that exposure to radium was the important ætiological factor. When, however, the blood examination of the other workers is also taken into account, the above conclusion becomes hardly open to doubt. The anæmia found was of exactly the same type, only less profound. Add to these facts the constant occurrence of a marked polynuclear leucopenia, and a complete absence of signs of regeneration, it is clear that the hematopoietic system of these workers is seriously damaged. In keeping with this view is the fact that recovery from the leucopenia is very slow. The effect of being away from radium exposure for several months is seen in the following figures obtained from two female clinical workers:—

	19/12	2/1	29/1	23/2	24/3	
Polynuclears	1382	2419	2254	3835	3484	Holiday
Lymphocytes	778	1210	1824	2665	1662	Dec. 5-Feb. 13
Polynuclears	1980	2364	2805	2419	1872	Holiday
Lymphocytes	1320	1576	2193	1599	1833	Dec. 5-Feb. 9

(Note the return of the leucopenia on returning to work.)

"The aplastic pernicious anæmia found differs from the rare disease of young women in being accompanied by a leucopenia instead of a leucocytosis. In this respect it is similar to certain anæmias produced by poisons, as, for instance, trinitrotoluol. In these a polynuclear leucopenia is often present, but in contrast to the present type a lymphocytosis occurs instead of a lymphopenia. (Minst).

"The experimental data dealing with the action of x-rays and radium radiations on the blood, spleen, and hematopoietic system are very extensive (Colwell and Russ). There is agreement in respect of the destruction of lymphocytes and of destructive changes in the tissues of the spleen. As regards the bone marrow under certain conditions of x-radiation, hyperactivity was observed, but whether this was due to the direct action of the radiation, or to a reaction to the destruction of circulating blood cells, was not decided. Destructive changes in bone marrow have also been described. It would seem probable that the very penetrating gamma rays of radium may have a destructive action on bone marrow, which relatively soft beta rays may not possess."

"In conclusion, it may be said that even those who are not entirely convinced that these deaths were directly due to this occupation will admit that the workers are suffering very serious damage, and that, therefore, they should be given every practicable and reasonable protection. Details of the various protective appliances in use at the Radium Institute are to be found in the annual report for 1919."

"I am indebted for the results of some of the blood examinations to Dr. Rubens Duval, Hospital St. Michel, Paris, and to Dr. J. W. H. Eyre, Guy's Hospital, London."

J. C. Mottram, M.B., D.P.H. Histological Changes in the Bone Marrow of Rats Exposed to the Gamma Radiations from Radium. Arlhives of Radiology and Electrotherapy, xxv, 197-199, Dec. 1920. From the Research Department of the Radium Institute, London.

"Twenty-three rats were taken. Of these eight were set aside for

controls, and fifteen for exposure. This was made a fair division as regards the sex, age and weight of the animals. The exposures varied from twelve hours to 460 hours, as shown in the table. Exposures above forty-eight hours were not continuous; the animals were irradiated for twelve hours during the night; during the day the radiation was discontinued. The animals were confined in a box 15 in. long and 9.5 in. wide. Varnished radium applicators (4 by 4 cm.), containing each 80 mgr. of radium bromide ($RaBr_2 2H_2O$), were placed at either end of the box, 9·5 in. from the center. The end of the box, which was made of deal 0·6 in. thick, and 2·25 mm. of lead, intervened between the animals and the applicator. The animals were killed when the exposure was complete, except in the case of some of the short exposures, when intervals of time up to three days were allowed to elapse."

"The bone marrow of the femur was fixed in Helly's mixture, and stained with eosin methylene blue, and with iron hæmatoxylin."

"Histological Findings. Two decided differences between control and experiment were noted in cases of exposures above forty-eight hours. The control specimens, mounted on the same slide as the experimental, stained much more deeply with iron hæmatoxylin, and a decidedly more intense blue with eosin methylene blue. Detailed examination showed this to be due to a diminution in numbers, in the radiated specimens, of young recently divided and darkly staining nuclei, and of nuclei in the anaphase. The more differentiated and granule containing cells presented no difference."

"The other observed difference was a decrease in the number of mitoses in the radiated specimens. To test this observation the mitoses were counted with a 1/12 in. objective, using a square diaphragm in the eye-piece to restrict the field. The sections were cut 3 microms thick, and only the central portion of a cross section of the bone marrow was used. Forty fields were counted in each case without knowledge of the specimen."

"The following figures were obtained:—

Eight controls		Fifteen experimentals		
	Mitoses		Exposures in hours	Mitoses
1	61	1	12	109
		2	12	87
2	74	3	24	110
		4	24	67
3	82	5	24	122
		6	24	46
4	85	7	48	65
		8	93	40
5	87	9	108	49
		10	139	36
6	89	11	280	43
		12	432	57
7	93	13	432	57
		14	432	47
8	104	15	460	41

"Discussion. These results are in keeping with and will explain the blood changes found in radium workers. The low polymorph blood

content commonly found, and the anæmia of an aplastic type affecting the much exposed workers, pointed to an interference with the output of blood cells from the bone marrow. Among x-ray workers there is rarely any evidence of such an effect, though a small fall in the number of circulating polymorphs and a mild anæmia has been noted in a few cases."

"Experiments on animals show that the bone marrow is less affected by x-rays than are lymphoid tissues. Warthin found an inhibition of white cell production and a preponderance of senile over young forms. It would seem that the penetrating gamma rays are able to reach the bone marrow, whereas the relatively soft x-rays used clinically fail in this respect. In view of the fact that a harder type of x-radiation is every day being more largely used, perhaps effects on bone marrow will in the future be observed and require to be guarded against."

MADAME MARIE CURIE'S VISIT TO THE UNITED STATES. A CORRECTION.

The editors are in receipt of a letter from the director of the Polish Bureau of Information, 40 W. 40th Street, New York City, and herewith reproduce the letter as a means of correcting a misstatement made in an earlier issue of this Journal.

New York, N. Y.,
June 22, 1921.

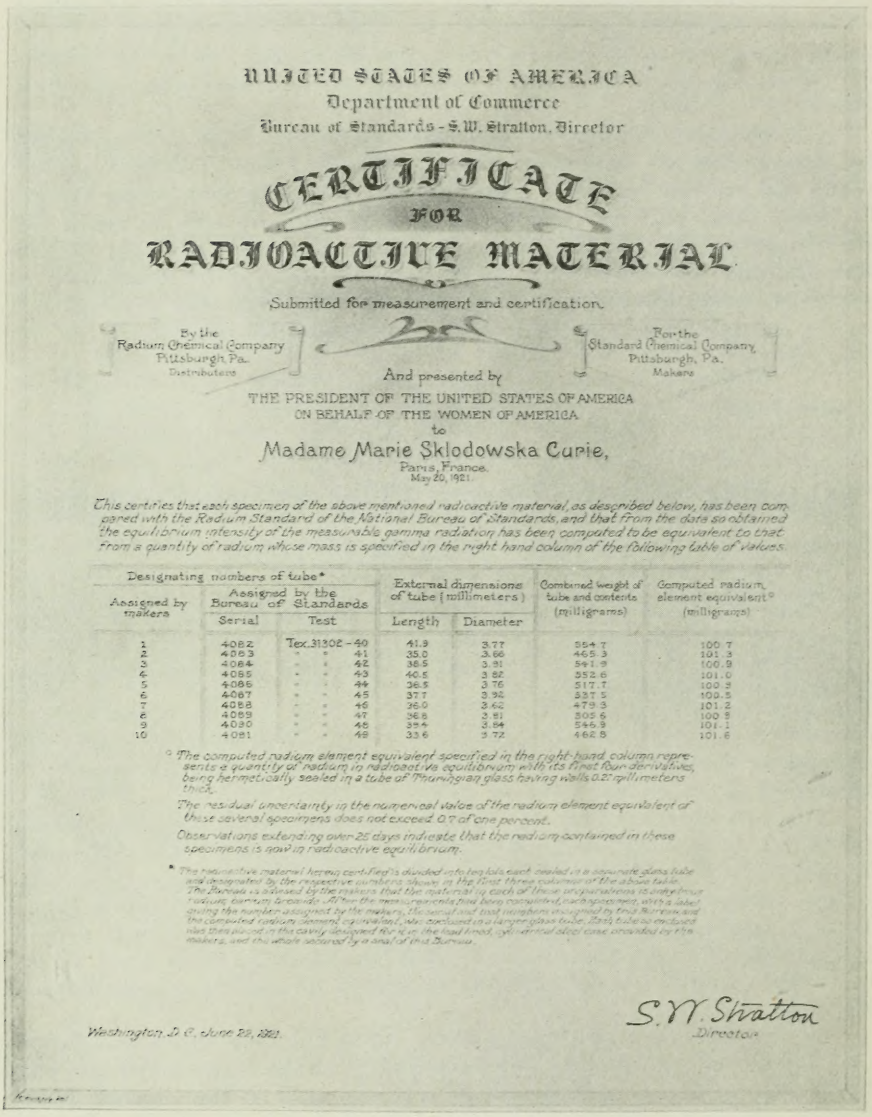
Dear Sirs:—

My attention has been called to a statement about Madame Curie's parentage in Radium, volume 17, No. 1, April 1921. The statement is said to be that Madame Curie's father, John Sklodowska (sic), was a Jew, while her mother was Swedish. This story was probably taken from a report in the New York Times, published last February, and corrected by Madame Curie's niece, Miss Dluska, in the New York Times of February 23rd. Apparently, the correction escaped your contributor's attention.

A few days ago the Chicago Daily News had an English translation of a Polish letter written by Madame Sklowdowska Curie while she was in Chicago to Mr. Czarnecki, of the editorial staff of the Chicago Daily News. Madame Curie states emphatically that she was born in Poland of Polish Roman Catholic parents of purely Polish extraction.

Hoping that you may see your way to correct this misstatement, I am,

Yours very truly,
(Signed) Ludwik Ehrlich, Director.



UNITED STATES OF AMERICA
Department of Commerce
Bureau of Standards - S. W. Stratton, Director

CERTIFICATE
FOR
RADIOACTIVE MATERIAL

Submitted for measurement and certification.

By the Radium Chemical Company, Pittsburgh, Pa. Distributors

For the Standard Chemical Company, Pittsburgh, Pa. Makers

And presented by
THE PRESIDENT OF THE UNITED STATES OF AMERICA
ON BEHALF OF THE WOMEN OF AMERICA
to
Madame Marie Sklodowska Curie,
Paris, France.
May 20, 1921.

This certifies that each specimen of the above mentioned radioactive material, as described below, has been compared with the Radium Standard of the National Bureau of Standards, and that from the data so obtained the equilibrium intensity of the measurable gamma radiation has been computed to be equivalent to that from a quantity of radium whose mass is specified in the right hand column of the following table of values.

Designating numbers of tube*		External dimensions of tube (millimeters)		Combined weight of tube and contents (milligrams)	Computed radium element equivalent° (milligrams)
Assigned by makers	Assigned by the Bureau of Standards				
	Serial Test	Length	Diameter		
1	4082 Tex.31302-40	41.9	3.77	584.7	100.7
2	4083 " " 41	35.0	3.66	465.3	101.3
3	4084 " " 42	38.5	3.91	541.9	100.9
4	4085 " " 43	40.5	3.82	552.6	101.0
5	4086 " " 44	36.5	3.76	517.7	100.3
6	4087 " " 45	37.7	3.92	537.5	100.5
7	4088 " " 46	36.0	3.62	479.3	101.2
8	4089 " " 47	36.8	3.81	505.6	100.9
9	4090 " " 48	39.4	3.84	546.9	101.1
10	4091 " " 49	33.6	3.72	462.8	101.6

° The computed radium element equivalent specified in the right-hand column represents a quantity of radium in radioactive equilibrium with its first four derivatives, being hermetically sealed in a tube of Thuringian glass having walls 0.21 millimeters thick.

The residual uncertainty in the numerical value of the radium element equivalent of these several specimens does not exceed 0.7 of one percent.

Observations extending over 25 days indicate that the radium contained in these specimens is now in radioactive equilibrium.

* The radioactive material hereon certified is divided into ten lots, each sealed in a separate glass tube and designated by the respective numbers shown in the first three columns of the above table. The Bureau is advised by the makers that the material in each of these unpacked tubes is only four radium, barium, bromide. After the measurements had been completed, each specimen, with a label giving the number assigned by the makers, the serial and test numbers assigned by this Bureau, and the computed radium element equivalent, was enclosed in a lampsilas tube. Ten tubes so enclosed was then placed in the cavity designed for it in the lead lined, cylindrical steel case provided by the makers, and the whole secured by a seal of this Bureau.

S. W. Stratton
Director

Washington, D. C. June 28, 1921.

THE MEASUREMENT OF MADAME CURIE'S GRAM OF RADIUM

Above is reproduced the specially engrossed certificate issued by the National Bureau of Standards in certifying the measurement of the gram of radium which was the gift of the women of the United States to Madame Curie. The total radium element content of the ten tubes is 1010.1 milligrams.

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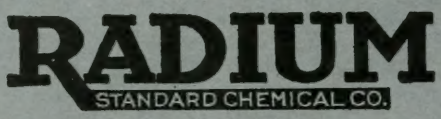

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